of the observed portion of the inner corona, the bolometric effect of its visual radiation may be supposed to be equal to that of the latter; but the observations above recorded show that the total radiations from the moon being 55+30, or eighty-five bolometric divisions, are seventeen times as great as the radiations from the inner corona, and hence it may be supposed that the corona lacks that large amount of infra-red radiation which is proper to the moon's spectrum.

The moon's spectrum, however, is that of a heated solid body, and all heated solid bodies, and heated gaseous bodies as well, send to the bolometer large amounts of infra-red radiation. So far, then, we might conclude that the inner corona has not the radiations of a hot solid or gaseous body, but, owing to the lack of a contemporary measure of the sky radiation just outside the corona, and of a full knowledge of the influences that the atmospheric radiations would have on our ability to discriminate this, the above conclusions seemed to me only probable, and worth verification at the forthcoming eclipse.

Smithsonian Institution, April 29. S. P. LANGLEY.

The Persistence of the Spectrum of Carbon Monoxide.

THE letter of Dr. Carl v. Wesendonk (p. 29), which gives an account of the spectrum of carbon monoxide appearing in a vacuum tube containing silicon tetrafluoride, affords an instance of the extreme difficulty of obtaining vacuum tubes charged with perfectly pure substances. The case he cites of silicon fluoride being prepared from "pure" sulphuric acid, glass and fluor spar, without any but glass joints to connect the different parts of the apparatus, is one in which neither the perfect freedom of the sulphuric acid, nor of the glass itself, from carbon compounds can be relied upon. In experiments on the absorption spectrum of ozone made by me in 1881, it was found that strong sulphuric acid free from all the usual impurities was not absolutely clear, but by being kept in an atmosphere containing a large proportion of ozone it became perfectly brilliant and absolutely colourless when seen in volumes of half a gallon to two gallons at a time. It appeared from further experiments that the impurities were either carbon or some form of organic matter probably coming from dust or dirt. As to the purity of the glass used for vacuum tubes, it may be remarked that dust and condensed vapour from carbonaceous matter, such as the products of combustion from lamp oil or coal, adheres to its surface with much tenacity. It is probable that the fluor spar contained organic matter, for the reason that this substance is associated with limestone of a bituminous character in England and that it has been asserted that its colour is due to organic substances. By the action of sulphuric acid a gaseous carbon compound might easily be evolved which would contaminate the silicon fluoride even if there were no carbonates present. Next we have to consider the traces of air which may remain in the tube, and must not regard these as being absolutely free from hydrocarbons. M. Armand Gautier has shown that there are combustible gases in the atmosphere, one of which is a hydrocarbon, the other hydrogen, and there is also some carbon monoxide. The difficulty of removing these by ordinary chemical treatment is so great that special operations and reagents were provided for their removal.

In vacuum tubes it is known that carbon monoxide shows its spectrum brilliantly when the pressure is extremely low, and that subsequently it disappears. The very interesting research of Prof. Smithells on "The Spectra of Carbon Compounds," in the April number of the *Phil. Mag.*, illustrates this. Furthermore, it shows distinctly that the same spectrum is obtainable from both carbon monoxide and carbon dioxide (*loc. cit.* pp. 489 and 490). We know, too, from the experiments of Regnault and of Bunsen on the analysis of atmospheric air, that carbon dioxide is absorbed by glass. In view of the facts quoted by Prof. Smithells, the carbon monoxide spectrum is, in his opinion, really due to carbon dioxide, but this latter may easily be decomposed into carbon monoxide and oxygen under the influence of the spark discharge.

The Swan spectrum, attributed variously to a hydrocarbon and to the element carbon by previous investigators, is, according to Smithells, to be attributed to carbon monoxide. It appears also in Dr. v. Wesendonk's letter that when the glass tubes in which the electrodes were fused had become heated, the carbon monoxide spectrum was faintly visible. This would be quite in accordance with the probability that carbon dioxide was evolved from the glass.

A tube containing silicon hydride also showed the carbon monoxide and the Swan spectrum, as well as hydrogen and mercury lines, but no silicon lines were observable. Considering all the facts of the case, it is not conceivable that the spectra in question arise in any way from the decomposition or dissociation of the silicon in the compound, either in the state of vapour as fluoride, of gas as hydride, or in the solid state as glass. W. N. HARTLEY.

April 25.

The Use of "Axis-vectors."

THE effort to popularise the elements of vector algebra is commendable. The power and the direct insight conferred by the use of vector quantities should be sought consistently in the study of physics; and it is true that the introduction of these methods has been needlessly postponed. But it lies in the very nature of such benefits that they are not to be secured except upon tenable grounds and as the result of a continuous argument. If a particular quantity is to be classed with vectors, that cannot be done upon a basis which is reducible to the bare statement: "This magnitude may be represented by a straight line of given direction and length; therefore it is a vector." Witness, for example, moment of inertia, which is not properly a vector, although its magnitude can be associated with a rotation-axis. Vector quantities must be subject to the process of "geometrical addition"; there is a total obtainable as the vector sum of constituent parts. This is equivalent to saying that there is a greatest value Q (resultant) for one direction, and that the law of orthogonal projection applies. Thus the value Q_1 for any other direction must satisfy the equation

$$Q_1 = Q \cos (Q_1, Q).$$

This projective property must be proved somehow in each case.

The conception of a vector is usually established as an elementary matter with the aid of instances like velocity and force. Velocity is so closely connected with linear displacement that the operations of geometrical addition and projection can be almost intuitively recognised as valid for both quantities. The graphical representation of forces, and the application to them of the "parallelogram construction," can be approached from the experimental side, furnishing a timely reminder that this procedure (as regards physical quantity) is ultimately justified by appeal to phenomena. The inclusion of "axis-vectors" (*e.g.* angular velocity and acceleration; moments of force and of momentum) in the class is a second step, of no less importance than the first. The proofs put forward to cover this extension of the thought afford fruitful material to the student of applied logic, through their variations of scope and emphasis. The analysis of some demonstrations now current prompts the remarks which follow.

First, linear vectors, like velocity, force, magnetic field, have what may be termed objective direction. But direction is assignable to axis-vectors by usage only, in the line of a (possible or actual) rotation-axis. Further, the sense in this line is arbitrary, being determined, for example, by the "rule of the right-handed screw." This double convention underlying the graphical representation of axis-vectors must be insisted upon.

Secondly, the theorem known as the "parallelogram of angular velocities" is really intended to prove that the linear velocities of all points in a rigid body satisfy the conditions of rotation in certain cases. The characteristic of rotation is a relation to the axis as regards the direction and the magnitude of all velocities, usually expressed as $v=r\omega$, v being perpendicular to both r and the rotation-axis. The proof of the theorem is only implicitly complete, if we content ourselves with showing that simultaneous angular velocities about intersecting axes produce zero linear velocity on a particular line. And the corollary covering the most important point is often not even mentioned. Similar considerations apply to angular acceleration.

Thirdly, the direct graphical representation of force-moment is connected with areas and not with lines. These areas are in general parallelograms, with adjacent sides representing the force and the distance of its point of application from a chosen point on the rotation-axis. The fundamental case is that in which the parallelogram is perpendicular to the axis, and its area shows the moment for a line through one vertex. For an oblique axis through the same vertex, the moment is obtained by projecting that area upon a plane perpendicular to the new axis. This follows easily from the definition of force-moment.

On adopting a convention governing signs, couple-moment can be represented, for a normal axis, by an algebraic sum of areas. The application here also of the projection-process is an immediate consequence, and it is seen that the values of couple-moment for all parallel axes are equal. The final step in making the transition to the axis-vector is the convention according to which areas are represented by lengths properly laid off on their normals. The process of reasoning for moment of momentum is entirely parallel to that outlined for moment of force. And it can be shown (cf. Heaviside, "Electromagnetic Theory," i. p. 181) to cover the cases of angular velocity and acceleration. For the representation of an area by a length of its normal is the basis of the idea in the vector product of two vectors. The argument of the present instance forms a good elementary introduction to that conception. F. SLATE.

University of California, April 24.

The New Comet.

ALTHOUGH others besides myself have probably noticed the remarkable inconsistencies in the published reports of the new comet, it seems worth while to draw attention to them. Its reported position for April 25, May 2 and May 4 are based on telegrams from the Cape and Peru, and there seems no reason to doubt their correctness. If, however, they are accurate, the comet could not have been seen in England in the morning, as at no time did it rise till after the sun. Yet Mr. Chambers saw it at Eastbourne at 3.5 a.m. on the 2nd, and a correspondent in the *Daily News* says it was fifteen degrees above the southern horizon at 3.30 a.m. on the 7th. E. C. WILLIS.

Southwell Lodge, Ipswich Road, Norwich, May 13.

Blood-Rain.

IN view of the recent letters in NATURE regarding the fall of red rain in Italy, the following extract from Roger of Wendover's Chronicles of the year 1223 may possibly be of interest:—"In the same year it rained blood-coloured earth at Rome for three days, to the great wonder of numbers of people (vol ii. p. 444 of Bohn's edition of Wendover's "Flowers of History.") It is rather curious that so miserably superstitious a *gobemouche* as Wendover should have described the phenomenon so accurately instead of calling it a rain of blood.

Polperro, Cornwall. F. H. PERRY-COSTE.

THE ANTI-VIVISECTION SOCIETY AND LORD LISTER.

THE Anti-Vivisection Society held its annual meeting last week in St. James's Hall. We know these annual meetings; they are accompanied by an annual crop of distortions of scientific work and an annual volley of scurrilous charges against scientific workers and philanthropic administrators. Beforehand, all the perseverance of the accomplished party "whip" is drawn upon to get these meetings together, and afterwards all the ingenuity of the unscrupulous pamphleteer to boom in the Press what has taken place at them. The usual copies of certain daily papers marked in blue pencil under the name of Mr. Stephen Coleridge are sent out broadcast, reporting in detail the sentiments of the audience and the horrors of so-called vivisectors. Were this all it might well be passed over in contemptuous silence, but this year it pleased the meeting to impugn the philanthropic impartiality of one whom all the scientific, and indeed cultured, world delights to honour.

Mr. Coleridge gravely informed his audience, after having discoursed inaccurately on Lord Lister's scientific work, that this man of science was the intimate friend of fifty-eight licensed vivisectors, presumably because he had signed a certificate exempting them from the use of anæsthetics in their scientific experiments. These certificates were signed by Lord Lister in his capacity as president of the Royal Society, and the probability is that personally he was not acquainted with half-a-dozen of the licensees. Mr. Coleridge carefully avoided telling his audience that the vast majority of these "horrid vivisections," in which the use of anæsthetics was dispensed with, were simply inoculations, or, in other words, mere pin-pricks; also that by the Prevention of Cruelty to Animals Act only very few persons of high scientific standing and training can sign these certificates, and that the president of the Royal Society is one.

Mr. Coleridge next turned his attention to scurrilous charges against Lord Lister, in particular, as chairman, and the committee, in general, of the Prince of Wales's Hospital Fund. He impugned the integrity of these gentlemen in that he stated they had given larger grants per bed to those hospitals which either had licensed laboratories attached to their medical schools, or had upon their staffs physicians and surgeons who were actually vivisecting, or had at some past time done so, than to those hospitals which had no connection either direct or remote with vivisectors. Further, that the Hospital Fund Committee had done this with the express object of encouraging so-called vivisection. Mr. Coleridge deduced the necessary corollary from this assertion, and stated point-blank that the Prince of Wales's Hospital Fund had simply been used to endow vivisection on a huge scale.

If we examine the facts we shall find that any hospital in London of any eminence whatever and performing philanthropic work of any magnitude, has upon its staff physicians and surgeons who have at one time or another experimented on animals. The small hospitals received small grants because their need was relatively small, and the large hospitals large grants because their need was relatively large, not because the former were unconnected and the latter connected with so-called vivisectors. Mr. Coleridge did not include in his speech the fact that he himself had endeavoured to strike a bargain with a London hospital, promising this institution the pecuniary support of the Anti-Vivisection Society if it would exclude from its staff all those whose medical knowledge had been derived from experiments upon living animals. The reply of this institution is worthy of record: it refused to allow any other considerations than those of medical or surgical efficiency to guide it in the choice of its officers.

This point has just now a very special interest, in that we believe that vivisection is to be made a party cry in the case of contributions to the Hospital Sunday Fund. Contributors are to be asked by the Anti-Vivisection Society when giving their contributions to demand that they shall only be devoted to hospitals having no connection with vivisectors or vivisection. So valuable have the results of experiments upon animals been to medical science that scarcely a hospital can be found independent of medical men who have derived their knowledge from them; and the Anti-Vivisection Society, with all its ingenuity and perseverance, cannot find amongst the ranks of its supporters a single medical man or indeed biologist of eminence. It is earnestly to be hoped that this fact will have its full weight with all contributors to hospitals, and that they will give their donations as they have done before, resting assured that their money will be duly apportioned by competent philanthropists accustomed to weighing justly the relative claims of charitable institutions, and not easily influenced by the clamourings, however loud, of ignorant partisans.

THE ARMY EDUCATION COMMITTEE.

WE are glad to learn that Sir Michael Foster has been added to the committee appointed to consider the present methods of selecting and training officers for the various branches of the Army. As stated in our number of May 2 (p. 23), this committee, as originally constituted, consisted of Colonel Jelf, Lieut.-Colonel Hammersley and Captain Lee, together with the Head Master of Eton, the High Master of St. Paul's, and the Right Hon. A. Akers-Douglas (chairman) and Captain Cairnes (secretary). Such a change as that